Sandia National Laboratories

Rock Blasting Computer Simulations

Need

A twelve year Work-For-Others project in the Geomechanics Department has produced and evolved a discrete element code [DMC_BLAST]. This code performs a coupled calculation involving gas flow and the particle motion to model the movement of rock during a blast. Rock movement during blasting is important to the ecomomics of most mines in the U.S. since it is more economical to move rock with explosives than with mechanical equipment. This mature computational capability is used to optimise blast designs and to guide the development of less sophisticated PC based blast modeling software. The most common blasting method in surface mines and quarries is the bench blast as seen in the picture below. Approximately vertical blastholes are drilled in rows that are parallel to the face of the bench and loaded with explosives. The explosives are detonated with precision delay times between the holes which also results in delay times between rows of blastholes. Explosive energy is employed to fragment and move the rock so that it can be mechanically excavated to expose the coal or to take quarry material to the crusher.

Another blasting method often employed in surface mineral mines is buffer blasting (sometimes called choke blasting). Surface mineral mines usually process low-grade ore by heap leaching methods. The grade of the ore can vary significantly throughout the mine depending on how the mineralization occurred in geologic time. Often a buffer blast will cover an area with both high-grade ore and waste. The boundaries are determined by assaying the blasthole drill cuttings. After the blast, polygons defining areas of ore and waste are surveyed for excavation. The surveying is done assuming that there has been no mixing of the ore and waste during the blast. Buffer blasting typically imparts far less energy to the rock than bench blasting and is designed to minimize rock movement. The purpose of buffer blasting is to fragment and loosen the rock sufficiently for excavation. Questions have arisen recently about how much buffer blasting really does move the rock causing some of the ore to go to the waste pile or some of the waste to be mixed in with the ore and dilute its grade.

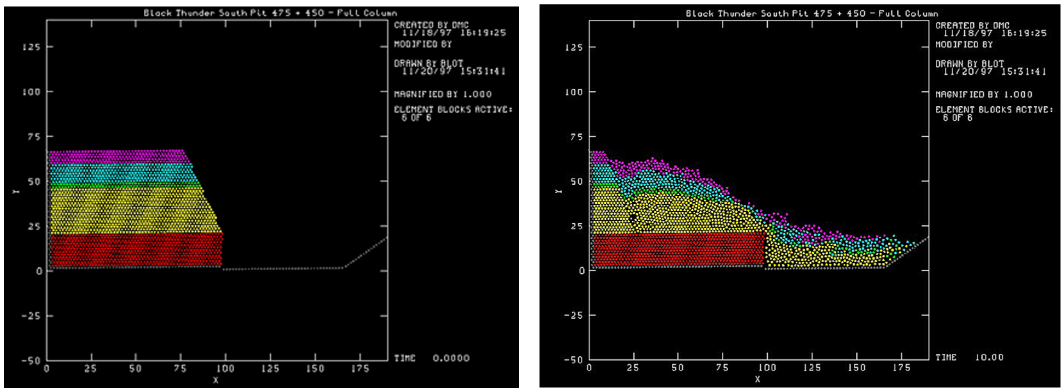
Description

A typical coal mine bench blast is shown in the picture to the right. The bench is ~90 feet tall and the pit is ~150 feet across. This blast was 1500 feet long and consumed 1.3 million lbs. of explosive (525 blastholes 10.5 inchs in diameter 80 feet deep). The explosive is detonated on a hole-by-hole basis with precise delay timing of at least 8 ms between holes. DMC_BLAST

Coal mine bench blast designed to fragment and remove the rock above a buried coal seam.

simulations of a coal mine bench blast are shown below. The red material at the bottom is the coal seam. Many blast design parameters can be varied for DMC_BLAST simulations to optimize the blast design. These parameters include explosive type, blasthole diameter, angle and depth, bench height, and spacing between blastholes both parallel and perpendicular to the face.

Discrete element simulation of rock motion induced by a bench blast.

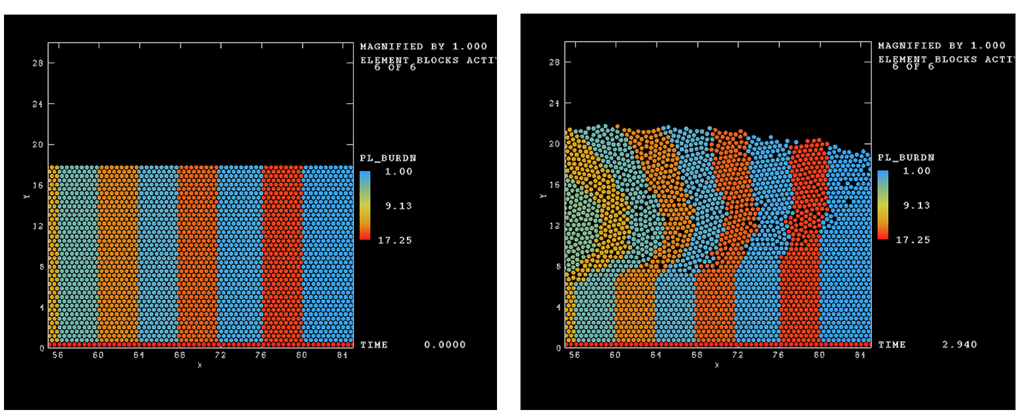


A U.S. low-grade ore gold mine is shown below with a buffer blast, both during and after the blast. In this particular blast there are free faces around the area of the blast though often there are not. The objective in buffer blasting is to break the rock and loosen it enough for efficient digging while controlling the blast-induced rock movement.

During and after a gold mine buffer blast designed to fragment the rock with minimal movement. Blast loads are very light to minimize mixing of ore and waste which are often adjacent to each other in the same blast. DMC_BLAST simulations have been used to guide blast design to minimize ore/waste mixing during blasting.

The DMC_BLAST simulation below shows a blasthole existing at each color boundary change. The original location of the rock between rows of blastholes is shown in the left picture with the final location of the rock in the right picture. Algorithms have been developed to calculate the ore waste and/or dilution associated with each blast design. This capability has been used to design buffer blasts to minimize ore waste and dilution.

Simulation of a buffer blast in a gold mine.



References

Preece, D. S., S. H. Chung, and J. P. Tidman, An Assessment of Ore Waste and Dilution Resulting From Buffer / Choke Blasting in Surface Gold Mines, Proceedings of the 24th Annual Conference on Explosives and Blasting Technique, International Society of Explosives Engineers, New Orleans, LA, February, 1998.

Preece, D. S., J. P. Tidman, and S. H. Chung, Expanded Rock Blast Modeling Capabilities of DMC_BLAST, Including Buffer Blasting, Proceedings of the 13th Annual Symposium on Explosives and Blasing Research, International Society of Explosives Engineers, Las Vegas, NV, February, 1997.

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